Federal Environmental, Industrial and Nuclear Supervision Service
(Rostekhnadzor of Russia)

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IN THE FIELD OF USE OF ATOMIC ENERGY

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ACCOUNTING OF EXTERNAL NATURAL AND MAN-INDUCED IMPACTS ON NUCLEAR FACILITIES

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ACCOUNTING OF EXTERNAL NATURAL AND MAN-INDUCED IMPACTS ON NUCLEAR FACILITIES, NP-064-05

Federal Environmental, Industrial and Nuclear Supervision Service

Moscow, 2005

These Federal standards and rules contain requirements for accounting of natural and man-induced external events during siting, design, construction, operation and decommissioning (including the prolonged surveillance) of nuclear facilities. These Federal standards and rules establish a list of natural and man-induced processes, phenomena and factors, which shall be identified in the course of surveys and studies in the region and on site of a nuclear facility and shall be accounted in its stability and safety justification.

These Federal standards and rules substitute PNAE G-05-035-94[*)].

These Federal standards and rules were developed on the basis of the legal acts of the Russian Federation, the Convention on Nuclear Safety, the Joint Convention on the Safe Management of Spent Nuclear Fuel and on the Safe Management of Radioactive Waste, federal standards and rules in the field of use of atomic energy, the IAEA safety standards, which include the "Regulatory Reviews and Assessments of Nuclear Facilities", "Preparedness and Response to Nuclear and Radiation Emergency", as well as documents of the IAEA safety series: "Siting", "Design", "Construction", "Operation" and "Decommissioning of Different Nuclear and Radiation Hazardous Facilities".

[*)] This revision of the regulatory document was developed in the Scientific and Engineering Center for Nuclear and Radiation Safety (I.V. Kaliberda, V.G. Bednyakov, E.G. Bugaev, I.M. Lavrov, L.F. Silaeva, V.P. Slutsker, V.V. Solovieva, L.M. Fikhieva) with participation of the IBRAE RAS (A.A. Polishuk), FSUE VNIIAM (S.P. Kazanovski), the Federal Environmental, Industrial and Nuclear Supervision Service (A.A. Lavrinovich, O.A. Makhnyuk) and FSUE Atomenergoproekt (Moscow) (V.N. Pogrebnyak).

The draft revision of this document considers and takes account of comments and proposals made by experts of the Federal Environmental, Industrial and Nuclear Supervision Service, the Department of Environmental Safety of the Ministry of Natural Resources of the Russian Federation, the Department for Nuclear and Radiation Safety and Department for Nuclear Material Industry of the Federal Atomic Energy Agency of the Russian Federation; experts of the European Union and the U.S. Department of Energy; and FSUE Atomenergoproekt (Moscow), FSUE SPbAEP (St. Petersburg), FSUE NIAEP (Nizhni Novgorod), VNIPIET, FSUE VNIIAM, IBRAE RAS, FSUE NIKIET, SUE TsNIISK named after V.A. Kucherenko, 26-th Central Research Institute of the Ministry of Defense of the Russian Federation, FC VNII GOChS of the MOE of Russia, GUGPS of the MOE of Russia, FSUE Production Association Mayak, FSUE Rosenergoatom Concern, DEB Rosenergoatomproekt, GSPI, FSUE OKBM, FSUE Siberian Chemical Combine, JSC TVEL.

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LIST OF ABBREVIATIONS

ASW	Air Shock Wave
MF	Maximum Flood
MSK-64	International Earthquake Intensity Scale
NF	Nuclear Facility[*)]
SSE	Safe Shutdown Earthquake

[*)] In some legal and regulatory technical documents and in previous revision of this document these facilities are also called nuclear and radiation hazardous facilities (NRHF).

MAIN TERMS, AND DEFINITIONS*

1. **ACCOUNTING OF EXTERNAL IMPACTS** shall mean the activities to ensure NF stability and safety under external events throughout its service life as relates to its siting, design, operation and decommissioning while taking into account external impacts at the NF site. The results of such activities are reflected in design and engineering solutions and organizational and engineering measures.
2. **DESIGN BASES** shall mean the combination of input data on required parameters and technical characteristics of NF, its systems, components, buildings, structures, including the data on conditions of its operation, process parameters and postulated external events for the purposes of NF design, manufacturing of its equipment, systems and devices, their assembling and adjustment, NF construction, ensurance of its normal operations during the assigned service life and its decommissioning.
3. **DETERMINISTIC APPROACH** shall mean the approach to design or engineering on the basis of fully defined data relevant to parameters of impacts and object properties which are knowingly introduced into safety margins to ensure that the limiting values of controlled parameters, established by guidelines, considering their margin coefficients are not exceeded.
4. **ENGINEERING PROTECTION OF NUCLEAR FACILITY FROM EXTERNAL IMPACTS** shall mean the set of engineered measures, site-wide planning solutions and organizational and technical measures to ensure stability and safety of NF and protect its buildings, structures, systems, components and employees aimed at prevention of accidents, including those associated with releases of radionuclides into the atmosphere and/or discharges of radionuclides to the aquifer or lithosphere under natural and/or man-induced impacts, as well as aimed at prevention or mitigation of economic and social losses.
5. **ENGINEERING PROTECTION OF NUCLEAR FACILITY SITE** shall mean the set of engineered measures and means to prevent or mitigate adverse effects of hazardous hydro-meteorological, geological and engineering and geological phenomena, processes and factors to the NF site.
6. **EXTERNAL IMPACT TO NUCLEAR FACILITY** shall mean the impact caused by an event, phenomenon or factor of man-induced or natural origin, which is external with regard to the nuclear facility.
7. **IMPACT** shall mean mechanical or physical effect or influence on NF buildings, structures, systems, components and personnel and/or population and environment.
8. **MAN-INDUCED IMPACT** shall mean the impact caused by human activity directly or as a result of the use of machinery and technology.
9. **MONITORING** shall mean the continuous survey of a process (phenomenon, factor) of natural or man-induced origin, state of the environment, facility as well as assessment and forecasting of their changes and development.
10. **NATURAL AND MAN-INDUCED CATASTROPHE** shall mean the catastrophe initiated by external impacts of natural or man-induced origin and accompanied by the consequences of global or regional scale associating with irreplaceable damage to the environment involving great human casualties, direct economic losses and consequence mitigation expenditure.
11. **NATURAL IMPACT** shall mean the impact caused by natural phenomena, processes and

* Adopted for the purposes of this document. The document also uses terms defined in the general safety provisions for different types of nuclear facilities.

factors that are external with regard to nuclear facility.

12. **NUCLEAR FACILITIES** shall mean the nuclear installations, radiation sources, nuclear material and radioactive substance storage facilities, and radioactive waste storage facilities, fuel assemblies of a nuclear reactor, irradiated fuel assemblies of a nuclear reactor, nuclear materials, radioactive substances, radioactive waste
13. **NF OPERATION SUPPORT** shall mean the monitoring and implementation of compensatory measures to ensure stability and safety of NF under external impacts.
14. **PROTECTION OF EMPLOYEES (PERSONNEL)** shall mean the set of technical and organizational measures that ensure required safety level for the personnel directly involved in NF control.
15. **PROTECTIVE BARRIERS** shall mean the set of engineered features to confine radioactive substances and ionizing radiation within the limits set forth by the NF design.
16. **RADIATION ACCIDENT CONSEQUENCES** shall mean the consequences (radiation situation) resulted from a radiation accident at NF.
17. **RISK** shall mean the combination of probability of a damage and severity of this damage expressed in adverse consequences (destruction, damage to the building, structure, system, component, NF operational event, NF accident and associated dangers of damage to human life and health and/or environment) due to natural or man-induced external events .
18. **SAFE DISTANCE (CONSIDERED)** shall mean the distance from a source of hazard to NF beyond which it is possible to neglect probable external natural or man-induced impacts to it.
19. **SAFETY ENSURANCE OF NUCLEAR FACILITY DURING EXTERNAL IMPACTS** shall mean the implementation of a set of engineering and technical and organizational measures at NF and aimed at prevention of exceeding the permissible safe operation limits and conditions during external events.
20. **SCENARIO OF FACILITY OR COMPLEX ENGINEERED SYSTEM STATES** shall mean the logical sequence of interrelated states of the facility or a complex engineered system, which are possible under natural and/or man-induced external impacts incorporated into the NF design bases.
21. **SEISMIC ISOLATION OF STRUCTURE (BUILDING)** shall mean the combination of engineering structures arranged, as a rule, in the structure foundations, which provide for reduction of oscillations of the structure being isolated with regard to seismic oscillations of the foot soils, as well as components and systems which provide for control (shift) of intrinsic frequency values of the structure (to the required range).
22. **STABILITY OF NUCLEAR FACILITY WITH REGARD TO EXTERNAL IMPACTS** shall mean the property of the facility characterized by stability of its safety important buildings, structures, systems and components, its protective barriers and facility safety for the population and environment under any types of external events.
23. **STABILITY OF SYSTEM (COMPONENT) TO EXTERNAL IMPACTS** shall mean the property of a system (component) to retain its performance of designated functions and maintain the pre-set parameter values during a pre-set time period in the normal operation conditions under natural and/or man-induced external impacts (seismic stability, vibration stability, corrosion resistance, etc.), within limits established by regulations and/or technical conditions for design and operation of the systems (components).
24. **SYSTEM WORKABILITY** shall mean the system capability to satisfactory perform assigned functions during the established period of time under prescribed operating limits and conditions.

1. PURPOSE AND SCOPE

1.1. These federal standards and rules contain requirements related to the accounting of external natural and man-induced impacts at siting, designing, constructing, operating and decommissioning (including the prolonged surveillance) of nuclear facilities.

1.2. The Rules establish:

- a list of processes, phenomena and factors of natural and man-induced origin and their hazard categorization;
- requirements to engineering surveys and studies of processes, phenomena and factors of natural and man-induced origin;
- site assessment categories with regard to the hazard degrees of processes, phenomena and factors of natural and man-induced origin;
- principles of NF stability and safety ensurance under external impacts;
- requirements to engineered protective features of the NF site;
- requirements for accounting of external impacts in NF siting, design, construction, operation and decommissioning;
- requirements for protection of NF against external impacts including protection of their systems, components and personnel who are directly involved in NF control;
- requirements for monitoring of NF stability under external impacts;
- requirements for monitoring of processes, phenomena and factors of natural and man-induced origin.

1.3. The Rules cover NF involved in:

- mining, enrichment and reprocessing of uranium and thorium ores;
- uranium conversion and enrichment;
- fabrication of nuclear fuel and radionuclide radiation sources;
- use of atomic energy for power supply (electricity and/or heat) or research;
- application of radioactive substances for scientific, medical and other purposes (customs control, warning about changes in environs, fires and other);
- storage of nuclear fuel, nuclear materials and radioactive substances;
- reprocessing of spent nuclear fuel;
- storage and disposal of radioactive waste.

1.4. The necessity and timeframe of bringing NF, which construction started before these Rules had come into effect, in compliance with these Rules shall be determined on the case-by-case basis in accordance with the established procedure. Relevant justifications shall be given in the NF Safety Analysis Report.

1.5. The Rules do not cover facilities, which contain or use nuclear materials or radiation substances in amounts and with activity (and/or emitting ionizing radiation with intensity or energy) which are less than the values established by the radiation safety standards and/or federal standards and rules in the field of use of atomic energy, and which require a permit from the state safety regulatory authorities for conducting activities at the said facilities.

Nuclear facilities where is case of destruction of all protective barriers (for example, due to a fire at the facility) possible exposure doses to the population beyond the facility leaktight barriers, at the controlled area boundary and beyond it will not exceed limits established for design basis accidents by the radiation safety standards shall be covered by general requirements for accounting of natural and man-induced external impacts set forth to general industrial and civil facilities.

1.6. The Rules do not cover nuclear power installations of ships, spacecrafts and other aircrafts, other nuclear-propelled vehicles and transportable nuclear installations, as well as shipments (transportation) of nuclear materials, radioactive substances and radioactive waste.

The Rules do not cover nuclear facilities under cognizance of the Ministry of Defense of the Russian Federation.

1.7. The Rules do not cover NF in case of external events caused by premeditated (terrorist, sabotage) actions, as well as those occurring under particular circumstances (hostilities).

2. LIST OF PROCESSES, PHENOMENA AND FACTORS OF NATURAL AND MAN-INDUCED ORIGIN. HAZARD CLASSIFICATION

2.1. The following List of processes, phenomena and factors of natural and man-induced origin shall be used as the guide when conducting engineering surveys and examinations in the region and site of NF location:

2.1.1. Hydrological and meteorological processes and phenomena:

- flood (flooding);
- tsunami;
- watercourse icing (ice jams, ice gorges);
- coastal situations (positive and negative setups, storms);
- seiches;
- tides;
- changes in water resources: extremely low flow, abnormal decrease in water level;
- tornado;
- wind;
- tropical cyclone (typhoon);
- atmospheric precipitation;
- extreme snowfalls and snowpacks;
- air temperature;
- snowslides;
- glaze-ice;
- lightning stroke.

2.1.2. Geological and engineering-geological processes and phenomena:

- fissure seismic and tectonic displacements, seismic dislocations, seismic and tectonic upswelling and downswelling of crustal blocks;
- modern differential crust movements including tectonic creep;
- residual seismic deformations of crust;
- earthquakes (of any genesis);
- volcanic eruption;
- mud volcanism;
- soil slips of any genesis;
- earthfalls and earth slip-falls;
- mudflows;

- snow and stone avalanches, crushed and block avalanches;
- erosion by water of shores, slopes and streams;
- sinks and subsidences;
- underground erosion including karst formation;
- congelation and geologic (cryogenic) processes;
- deformation of specific soils (karst, thermokarst, dilution, solifluction, suffusion processes).

2.1.3. Factors creating external impacts of man-induced origin (man-induced factors):

- air craft and other projectile crash;
- fire due to external cause;
- on-site explosion;
- release of explosive, flammable and toxic vapors, gases and aerosols into the atmosphere, drifting cloud explosion;
- corrosive liquid discharged into surface and groundwater;
- electromagnetic radiation;
- spills of oil and oil products at the coastal aquifer surface areas of seas, rivers and oceans;
- break of natural and artificial reservoirs.

2.2. The three hazard degrees are established with regard to the processes, phenomena and factors of natural and man-induced origin depending on impact consequences for the environment:

Hazard Degree I – an especially hazardous process (phenomenon, factor), which is characterized by the maximum possible for the given process values of parameters and characteristics within a preset period of time and accompanied by natural and/or man-induced catastrophes;

Hazard Degree II – a hazardous process (phenomenon, factor), which is characterized by sufficiently high (but not higher than the known maximum value for the given process) values of parameters and characteristics within a preset period of time and accompanied by tangible consequences for the environment;

Hazard Degree III – a process (phenomenon, factor), which does not pose any danger and is characterized by low values of parameters and characteristics within a preset period of time and is not accompanied by tangible consequences for the environment.

2.3. Hazard of natural and man-induced processes, phenomena and factors revealed in the NF location and site region shall be determined on the basis of calculated maximum values of their impact parameters (intensity and frequency) using the limiting values set forth for them and presented in Appendix 1.

2.4. Maximum parameter values of the hydrometeorological, geologic and engineering-geological phenomena and processes shall be determined for the time interval of 10,000 years.

The design bases shall consider man-induced factors with the frequency of occurrence equal of greater than 10^{-6} 1/year. When calculating the occurrence frequency of a man-induced factor, its maximum design intensity and other impact parameters the experience in operation of similar facilities with similar man-induced impact sources and data of many-year observations in the NF region and site within possible impact zones shall be considered.

Parameters of possible man-induced impact due to these operational events shall be determined using the said analysis results and considering a distance between NF and the source of hazard.

Values of maximum design parameters of processes, phenomena and factors of natural and man-induced origin shall be determined with confidence which does not exceed their mean calculated (expectancy) value of 0.95.

2.5. While determining a degree of hazard of the processes, phenomena and factors of natural and man-induced origin for particular local conditions, a possibility for the processes, phenomena and factors be accompanied by other interrelated and interdependent processes (phenomena and/or factors), which may affect a NF safety shall be considered. Parameters of these processes, phenomena and factors shall also be determined and categorized in terms of their hazard degree in accordance with the requirements of para. 2.3 and 2.4 of this document. In so doing, the list of interrelated and interdependent natural processes given in Appendix 2 shall be guided by.

The development scenarios shall be worked out for processes and factors of man-induced, natural and man-induced, and man-induced and natural origin to identify a degree of their interrelation and interdependence.

2.6. Nuclear facility sites shall be categorized depending on a hazard degree of processes, phenomena and factors they feature. There are three classes of sites:

2.6.1. Class A shall denote the sites which do not feature external impacts of Hazard Degree I and II.

2.6.2. Class B shall denote the sites which do not feature external impacts of Hazard Degree I.

2.6.3. Class C shall denote the sites which feature external impacts of Hazard Degree I, II and III.

2.7. The NF design bases shall include values of maximum design intensities of external events caused by processes, phenomena and factors of natural and man-induced origin with a likelihood to occur at the NF site, values of other necessary parameters of external impacts, as well as the data of many-year observations of the atmosphere (inversions, fogs, dust storms) in the NF region and site, and hydrogeological characteristics of soils and water-bearing layers revealed in the NF region and site.

3. REQUIREMENTS TO ENGINEERING SURVEYS AND STUDIES OF NATURAL AND MAN-INDUCED PROCESSES, PHENOMENA AND FACTORS

3.1. Surveys, as well as studies, based on complete and reliable information including that from sources listed in Appendix 3 shall be carried out to reveal and identify natural and man-induced processes, phenomena and factors.

3.2. An Engineering Survey and Study Program for the NF site and region shall be developed on the facility-specific basis. The NF site features include a degree of potential radiation hazard for the personnel, population and environment, facility layout, its location, service life, possibility of on-site storage of spent nuclear fuel, nuclear materials and radioactive substances, radioactive waste storage and disposal.

3.3. The NF site and location region shall be studied to identify whether the natural and man-induced hazardous processes, phenomena and factors, as per Chapter 2 list, pertain to the site; to assess a possibility of their interaction; to predict their development sequence, and to determine their maximum design parameters.

The surveys shall be carried out with regard to natural and man-induced phenomena, processes and factors within the radial distances of the NF site determined in accordance with the federal standards and rules, safety guides and other documents in the field of use of atomic energy.

The list of main parameters for describing natural and man-induced hazardous processes, phenomena and factors shall be sufficient for accounting of their possible impact to the NS site and NF. The recommended set of main parameters for description of natural and man-induced processes, phenomena and factors is given in Appendix 4.

3.4. The man-induced hazard sources shall be identified for the NF location region taking into account the features of existing and prospective development of the area adjacent to the site.

3.5. The consideration and hazard degree identification results for phenomena, processes and factors of the region and NF site shall be given in the NF safety analysis report.

3.6. Methods of engineering surveys and studies, as well as that of analysis and determination of parameters of processes, phenomena and factors of natural and man-induced origin shall ensure completeness of the information being obtained, its credibility for defining maximum design values of external impacts, identification of interrelation of processes and mechanisms of affecting the environment and facility (its systems and components).

4. PRINCIPLES AND CRITERIA OF NF STABILITY AND SAFETY ENSURANCE UNDER EXTERNAL IMPACTS

4.1. The NF stability and safety under the external impacts shall be ensured. The NF shall be sited, designed constructed, operated and decommissioned considering possible external impacts on its site. The NF safety important systems and components shall have the degree of stability to withstand external impacts featured by the NF site.

4.2. In case of external impacts at NF:

4.2.1. The impermissible (in terms of safety function performance) damages or failures of the safety important systems, components, buildings and structures shall be prevented;

4.2.2. Effects of external impacts with regard to an increase in frequency and severity values of consequences calculated for design basis accidents caused by internal initiating events shall be excluded;

4.2.3. Protective barriers, which prevent radioactive releases and discharges into the environment or keep their quantities and/or activity within the limits permitted by radiation safety standards during a prolonged period of time following an accident, shall be maintained.

4.3. The NF safety under the external impacts shall be achieved also through:

- selection of a NF location that meets safety criteria and requirements established in the federal standards and rules in the field of use of atomic energy;
- NF design which is stable to external impacts possible at its site location;
- supervision over NF operations with regard to accounting of external impacts (monitoring of development of hazardous processes and how the buildings and structures, safety important systems and components respond to them; implementation of compensatory measures (safe shutdown) of the facility in cases where maximum intensity level of impacts, as accepted in the design bases, is exceeded; implementation of technical measures to protect the personnel who are directly involved in the facility control against adverse consequences of impacts);
- creation of conditions for implementation of emergency plans, including evacuation of the employees and population from the accident area, if the accident is triggered by external impacts.

5. REQUIREMENTS TO ENGINEERED PROTECTIVE FEATURES OF NF SITE

5.1. Before NF construction or during its upgrade at the NF site categorized as Class B or C, the engineered protective measures shall be taken to prevent or reduce adverse effects of the natural and man-induced processes, phenomena and factors to the NF site; this shall be

done with consideration of scenarios of the processes development, their interrelation and interdependence. .

5.2. The engineered protective features of the NF site shall be implemented in accordance with the requirements of federal standards and rules in the field of use of atomic energy. Should these engineered protection standards and rules be unavailable, the proposed specific engineering solutions shall be justified and determined by the developer and agreed upon with the state safety regulatory authority in accordance with the established procedure.

5.3. The compatibility and efficiency of combined functioning of the protective features intended for engineered protection of the NF site from various external impacts shall be ensured. A list of recommended protective measures of engineered protection of the NF site is given in Appendix 5.

5.3. When NFs are located at Class B and C sites the evacuation routes for the personnel and population shall be analyzed and protected (if necessary) to prevent formation of temporary obstacles on them (landslides, avalanches, floods, fractures, etc.).

5.4. When selecting a NF site, to avoid the necessity to implement protective measures at the NF location area and to reduce risks of adverse consequences of external impacts the preference shall be given to the site featuring lower intensity of external impacts (Class A and B sites).

6. REQUIREMENTS FOR ACCOUNTING OF EXTERNAL IMPACTS DURING SITING, DESIGN, CONSTRUCTION, OPERATION AND DECOMMISSIONING OF NUCLEAR FACILITIES

6.1. When siting NF the site suitability for locating the NF shall be assessed taking into account the site class in accordance with para 2.6 and results of NF preliminary assessments of NF safety under external impacts done at the stage of siting.

6.2. NFs shall be designed taking account of the external impacts laid out in the design bases.

A list of NF buildings, structures, systems and components elements subject to analysis of stability to a certain external impact shall be compiled through considering external impact scenarios and their consequences for the nuclear facility.

To compile the list of buildings, structures, systems and components it is required to analyze scenarios of external impact developments and their consequences for the NF; it shall be done using a logical scheme of the facility safety analysis of a nuclear facility given in Appendix 6.

The list shall include buildings, structures, systems and components, which are to be affected by the given impact. They shall be selected out of the NF safety important buildings, structures, systems and components as well as of those, not safety related, which destruction, damage or failures can affect NF safety under an external event.

When compiling the lists of buildings, structures, systems and components subject to the analysis of stability to external impacts considered in the design bases all probable interdependent and interrelated primary (for example, an earthquake) and secondary effects of external impacts to NF (for example, a landslide, dam break, soil subsidence, building banking and settling, collapse of overlappings, pipeline breaks, jets, projectiles, fire etc.) shall be considered.

6.3. The NF buildings, structures, systems and elements subject to analysis of stability to external impacts shall be assessed with regard to each type of impacts considered in the design bases.

For each building, structure, system and component the design stability criteria regarding loads caused by external impacts shall be determined in the design, including loads caused by secondary effects; this shall be done considering standards and criteria (strength, vibration strength, seismic resistance and stability) established in regulatory documents or obtained through experimental justifications, as well as taking into account features of engineering and layout solutions and operating experience.

6.4. In the course of the stability analysis of a NF building, structure, system or component it shall be ensured that the design stability criteria are not exceeded in regard to the following parameters:

- deformation, displacement and deflection;
- settling and banking of buildings and structures;
- reliability of anchoring of units, equipment and components;
- thermal and corrosion resistance of structural materials;
- strength and durability;
- leaktightness (gas and smoke tightness) of facility inner volumes;
- performance of structures, systems and components;
- fire resistance.

6.5. The NF design with consideration of external impacts shall be carried out on the basis of the deterministic approach. Deterministic values of parameters of maximum design impacts from natural and man-induced processes, phenomena and factors and deterministic parameter values of the facility itself (properties and characteristics of foundation soils, structural materials of structures, systems, components, supports) shall be used for assessments of stability of buildings, structures, systems and components under external impacts.

6.6. For the purposes of strength and stability assessment under external impacts adopted in the design bases, for each NF building, structure, system and component the basic and possible specific combinations of loads shall be determined. The basic combination of loads shall include loads arising from normal operation (dead loads, temporary loads). Specific combinations of loads shall include the basic combination of loads and one of loads resulting from external impacts (sustained loads or short-time loads). A number of combinations shall be equal to the number of types of external impacts considered in the design bases of the NF building, structure, system or component being analyzed.

It is permitted not to consider combinations of loads resulting from operational events, including design basis accidents, and loads resulting from external events with regard to NF buildings, structures, systems and components which do not pertain to nuclear installations.

6.7. Assessments of NF buildings, structures, systems and components' stability to external impacts shall be carried out using analysis and calculation methods, input data and software which confidence is justified.

6.8. In case of each newly designed NF, which in case of an accident may potentially lead, due to its hazard degree, to a global or regional man-induced catastrophe under low intensity levels of external impacts (Degree of Hazard III) as assumed in the design bases, the following shall be ensured:

seismic stability at accelerations of not less than 0.1 g (of acceleration of gravity) at the building foot level;

stability to loads produced by the air shock wave of not less than 10 kPa front pressure with contraction phase time of up to 1 s;

fire resistance of safety important buildings and structures to the external fires during not less than 1.5 hours in the event of standard fire;

stability of the localizing system protective structures to local impact loads produced by aircrafts and other projectiles' crash, which are equal to and not less than, in the contact area, the impact loads produced by crash of a light airplane (5 t);

spatial and physical separation of safety systems and their channels.

6.9. The protection against possible impacts to NF produced by facilities posing potential threat to NF (radiation, air shock wave, fire hazards, electromagnetic radiation, corrosive releases and discharges, releases of toxic gases and aerosols, etc.) shall be ensured at the siting stage by remote locating of NF and observing safe distances from these facilities. Such distances shall be established in accordance with the corresponding federal standards and rules in the field of use of atomic energy on the basis of the safety analyses. In accordance with the established procedure the developer shall agree with the state safety regulatory authority the technical justifications of waivers to locate facilities posing hazard to the NF remotely and proposed engineering solutions to protect NF from their impacts.

6.10. A waiver to carry out measures to exclude damages to safety important buildings and structures of the operating NF due to external impacts shall be justified by proving that:

- impermissible failures and damages to the safety important systems and components are excluded;
- the values of the design basis accident frequencies and their consequence severity calculated by the NF probabilistic safety analyses of external impacts do not change significantly as compared to the results of the NF probabilistic safety analyses of internal initiating events leading to design basis accidents; and that they are acceptable;
- frequency of beyond design basis accidents due to natural and man-induced external events is sufficiently low (less than 10^{-6} 1/year) or the value of limiting accident release (discharge) probability in case of beyond design basis accidents due to natural and man-induced external events is less than less than 10^{-7} 1/year.

6.11. The selection of NF engineered protective features shall be justified from the point of view of reliability, efficiency and sufficiency in one or several ways:

calculations;

previous operating experience gained at prototypes of protective features;

testing of buildings, structures, systems and components or their mock-ups adequately reflecting the actual object features and characteristics;

conformance to the requirements of relevant safety guides;

achievements of science and technology.

A list of recommended engineered protective measures for NF against external impacts is given in Appendix 5.

6.12. The measures adopted in the NF design to protect safety important systems and components shall be sufficient to ensure NF safety at the stages of operation, decommissioning as well as prolonged surveillance.

6.13. To ensure NF safety at the stage of commissioning the dynamic characteristics (decay and frequency of natural vibrations) of safety important systems and components (except for buildings and structures) shall be studied. These studies shall use the methods of experimental research or dynamic tests and be carried out in accordance with the procedure, methodology, scope established in the design documentation.

For NF in operation the dynamic characteristics of safety important systems and components shall be determined by calculations in accordance with the design bases and then verified by studies or tests in the course of NF operation and at shutdown and rendered safe NF (for example, during an NF scheduled outage).

Data on the updated dynamic characteristics of the components shall be used in the NF safety analyses and reflected in the relevant safety analysis reports.

6.14. The personnel involved in control of NF located in high seismisity sites (SSE of magnitude 7 and higher) or attributed to Hazard Category I sites due to processes, phenomena and factors featuring mechanical dynamic impacts (explosion, projectile crash) shall be protected by features excluding adverse effects to such personnel from external impacts. The necessity to protect the personnel who are directly involved in the NF control from external impacts shall be determined on the basis of an analysis of possible ultimate consequences of external events to this personnel and numerical values of possible loads. The protection of the personnel who are directly involved in the NF control is required in cases where it has been determined that loads to the personnel can exceed the safe load levels. Recommended safe load levels are given in Appendix 7.

Sufficiency and reliability of protection against external impacts of the personnel who are directly involved in the NF control shall be justified in the design.

A list of recommended equipment for collective and/or individual protection of the personnel against external impacts (and their consequences) is given in Appendix 8.

6.15. The NF probabilistic safety analyses regarding external events shall be carried out to obtain estimations of risk of accidents at NF under external impacts. Assessments of risks of adverse consequences for the NF site under external impacts shall be taken into account when the NF stability and safety is ensured at the stage of the NF design and operation.

6.16. Results of the assessments of accident risks at the NF due to external events shall be considered in the course of the development of emergency plans.

6.17. The operating documentation shall prescribe behavior of the operator of a reactor installation, nuclear fuel fabrication installation and spent nuclear fuel processing installation, as well as actions of the personnel of other NFs who are directly involved in NF control in the event of emergencies in case of a threat of external impacts.

6.18. For NF representing nuclear installations (considering their high potential nuclear and radiation hazard) which design bases consider natural and man-induced dynamic external impacts of Hazard Degree I the design shall provide for automated systems for recording such impacts and automatic facility shutdown systems which operate in parallel.

Automatic facility shutdown systems of nuclear installations shall perform the designated functions in cases where reference levels of external event intensity are exceeded. These levels shall be determined in the design for settings of external event recording sensors (detectors).

6.19. The NF shall be shutdown automatically or manually in case of a dynamic natural or man-induced external event on the NF site (earthquake, external explosion and aircraft crash) when the reference levels of external event intensity, adopted in the design with a sufficient degree of conservatism, are exceeded. Numeric values of parameters adopted as reference levels shall be justified in the design and referenced in the NF safety analysis reports.

6.20. If a natural or man-induced dynamic process, phenomenon or factor with intensity corresponding to Hazard Degree I or II has occurred at the NF site the surveys and analysis of conditions of NF buildings, structures, systems and components shall be carried out to assess the possibility of their further safe operation.

6.21. At the stages of NF operation and decommissioning (including the prolonged surveillance) the monitoring of NF stability with regard to external events shall be carried out through:

- observation of conditions of soil subsidence of foundations of safety important buildings and structures;

- assessment, analysis and projection of conditions of safety important buildings, structures, units of civil engineering structures, including assessments, analyses and projections of banking and settlement of these buildings;
- analysis of condition of protective barriers and projection of their reliability as based on results of inspections and technical examinations;
- periodic inspections and tests of protective features (seismic insulation, isolators, etc.), fire protection systems and bunds on the NF site;
- performance inspection of measuring, recording and information transmitting hardware used for warning about and protection from external impacts;
- inspection of availability and orderliness of the personal and group protective equipment for the personnel directly involved in NF control;

6.22. The NF shall compile and continuously update databases on natural and man-induced processes, phenomena and factors at the NF site and region.

Recommended formats of databases on natural and man-induced processes, phenomena and factors are given in Appendix 9.

6.23. If the in-service monitoring of the nuclear facility records changes in the design parameters of external impacts considered in the design bases, the consequences of such changes for the NF stability and safety shall be assessed and, if necessary, additional engineered protective measures regarding NF and/or NF territory shall be taken.

6.24. Protection of the NF safety important buildings, structures, systems and components from external events shall be ensured while nuclear materials and radioactive substances are on the NF site and the NF is a source of radiation hazard.

6.25. In case of prolonged surveillance of NF containing nuclear materials, radioactive substances and radioactive waste, it is necessary to provide for seismic stability of the safety important structures, including their long-term strength considering a possibility for external impacts, considered in the design bases, to occur over the entire surveillance period established in the design.

6.26. The NF decommissioning project shall provide measures to ensure stability of civil engineering structures under external impacts during all stages of the decommissioning work execution.

7. REQUIREMENTS FOR MONITORING OF PARAMETERS OF NATURAL PROCESSES, AND PHENOMENA AND PERIODIC MONITORING OF MAN-INDUCED FACTORS

7.1. In the NF region and site the monitoring shall be ensured of the parameters of natural processes and phenomena incorporated in the design bases, as well as the periodic monitoring shall be ensured of the parameters of man-induced factors, incorporated in the design bases, at all stages of the NF life cycle.

7.2. If Hazard Degree I and II natural processes and phenomena are possible to occur on the NF site, the systems for monitoring of their parameters shall be operable before the NF commissioning.

7.3. The monitoring systems shall perform the designated functions in accordance with design requirements during the entire life of the nuclear facility.

7.4. The equipment for monitoring and periodic inspection of parameters of processes, phenomena and factors shall be subjected to checkups. The checkup frequency shall be established in the design documentation of the monitoring and periodic inspection systems and shall be sufficient to ensure their fail-free operation between the checkups.

7.5. The monitoring systems of natural processes and phenomena shall be integrated into unified state-level systems for monitoring, which are available in the Russian Federation and located in the NF site region.

APPENDIX 1: CATEGORIZATION OF PROCESSES, PHENOMENA AND FACTORS OF NATURAL AND MAN-INDUCED ORIGIN (MANDATORY) BY DEGREE OF HAZARD OF CONSEQUENCES OF IMPACT TO THE ENVIRONMENT

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
I. HYDRO-METEOROLOGICAL PROCESSES AND PHENOMENA			
Flood (flooding)	NF site flood (flooding). Hydrochemical and dynamic impacts to buildings, structures and utilities	Flooding level is 1 m or less; water current is 0.7 m/s or less	I
the same	the same	Flooding level is less than 1 m, but more than 0.2 m; water current up to 0.7 m/s	II
,,	Underflooding of NF site	Flooding level is 0.2 m and less	III
Tsunami	Flooding of NF site Dynamic impact of tsunami to buildings and structures Temporary decrease in water level at coastal area	Wave height is 5 m or more; water level height on-shore is 1 m or more	I
the same	the same	Wave height is less than 5 m but more than 0.2 m; water level height on-shore is less than 1 m but more than 0.2 m	II
“	"	Wave height is 0.2 m or more; water level height on-shore is 0.2 m or more	III
Watercourse icing (jams and gorges)	Flooding of the NF site, dynamic impacts due to blow wave	Flooding of the territory is 1 m or more. Dynamic impact parameters are determined by calculations.	I
the same	Flooding of the NF site, dynamic impacts due to blow wave (clogging of NF water intakes and	Dynamic impact parameters are determined by calculations. Flooding	II

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
	piping by crashed ice)	level is less than 1 m but more than 0.2 m.	
the same	the same	Dynamic impact parameters are determined by calculations. Flooding level is 0.2 m or less	III
Coastal situations (positive and negative setups, storms)	Flooding of NF site. Dynamic impacts to vertical and slope profile hydraulic structures. Flow over barriers and conveyance structures.	Flood level is 1.0 m or more. Dynamic loads are determined by calculations.	I
the same	the same	Flood level is less than 1 m but more than 0.2 m. Dynamic loads are determined by calculations.	II
the same	the same	Flood level is 0.2 m or less	III
Seiches	Flooding of NF site	Flood depth is 1 m or more.	I
the same	the same	Flood depth is less than 1 m but more than 0.2 m	II
the same	the same	Flood depth is 0.2 m or less	III
Tides	Flooding of NF site.	Flood depth/drainage is 1 m or more but ≥ 2m	I
the same	the same	Flood depth is less than 1 m but more than 0.2 m	II
the same	the same	Flood depth is 0.2 m or less	III
Changes in water resources: extremely low flow, abnormal decrease in water level	Decrease of water level at NF process water supply surface sources	Flood drainage is more than 0.2 m less	II
the same	the same	Flood drainage is 0.2 m or less	III
Tornado	Gust affecting buildings and structures. Loads due to pressure differential between periphery and funnel	Maximum horizontal rotation speed of the tornado wall: 50 m/s or more.	I

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
	rotation center. Loads produced by projectiles captured by tornado. Capturing of water from process cooling ponds	Pressure differential is 3 kPa or more; intensity scale class F2 and higher, path length is 15 km or more; path width is 50 m or more. Projectile dynamic loads and reservoir drainage depth are determined by calculations.	
the same	the same	Maximum horizontal rotation speed of the tornado wall is less 50 m/s but more than 7 m/s. Pressure differential is less than 3 kPa; intensity scale class F1, path length is less than 15 km; path width is less than 50 m but more than 16 m. Projectile dynamic loads and reservoir drainage depth are determined by calculations.	II
,,	,,	Maximum horizontal rotation speed of the tornado wall is 7 m/s or less. Pressure differential is 1 kPa; intensity scale class F0 or less, path length is 1.5 km and less; path width is 16 m or less. Projectile dynamic loads and reservoir drainage depth are determined by calculations.	III
Wind (hurricane)	Gust Projectiles	Wind speed is 35 m/s or more. Projectile dynamic loads are determined by calculations.	I
Wind	Gust Projectiles	Wind speed is less than 35 m/s but 7 m/s or more. Projectile dynamic loads are determined by calculations	II

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
the same	the same	Wind speed is less than 7 m/c	III
Tropical cyclone (typhoon)	Gust affecting buildings and structures Rainstorms	Precipitation depth is 30 mm/h or more, wind speed is 35 m/s or more	I
Atmospheric precipitation	Flooding of the site	Precipitation depth is 50 mm or more within 12 h (in mudflow regions: 30 mm or more within 12 h or less)	I
the same	Flooding of the site	Precipitation depth is less than 50 mm but more than 30 mm within 12 h or less	II
the same	the same	Precipitation depth is less than 30 mm or more within 12 h or less	III
Extreme snowfalls and snowpacks:			
Extreme snowfalls	Snow banks on access roads, sections, communication lines, etc.	Precipitation depth is 20 mm/h or more within 12 h or less	II
Extreme snowpacks	Snow loads to building and structure roofs	Precipitation depth is determined by calculations	II
Air temperature	Temperature loads to buildings, structures, utilities, etc.	Maximum values of positive and negative temperatures, their differentials and temperature gradients are determined by calculations.	II
Snowslide	Dynamic snow pressure. Air shock wave	Relief axial division depth 500-1,000 m; mean maximum snow depth 70 – 100 cm	I
the same	Dynamic snow pressure	Relief axial division depth 500 m or less; mean maximum snow depth is less than 70 cm	II
Glaze-ice	Destruction of communication and	Ice thickness is more than 25 mm.	I

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
	electricity transmission line supports. Communication and electricity transmission line failures due to icing, glazed frost		
the same	Overloading of building structures due to icing, glazed frost, etc.	Ice thickness is more than 3 mm.	II
the same	the same	Ice thickness is 3 mm or less	III
Lightning stroke	Electric discharge impact to buildings, structures, utilities, equipment	To be determined by calculations considering thunderstorm hazards in the region and electric field intensity.	II
II. GEOLOGIC AND ENGINEERING GEOLOGIC PROCESSES AND PHENOMENA			
Fissure seismic and tectonic displacements, seismic dislocations, seismic-tectonic elevations and sinking of crust blocks	Fast fault, shear, thrust, upthrust, strike-slip fault and other crustal faults accompanied by severe oscillations (magnitude 8 as per MSK-64 scale)	Fissure pulse displacements with amplitude of 0.3 m or more	I
Modern differential crust movements, tectonic creep	Slow fissure and folding movements accompanied by rock deformations and fissure shifts	Fissure shift is 0.3 m or more. Geodynamic zones with quaternary movement speed gradient 10^{-6} m a year and greater.	I
the same	the same	Fissure shift is less than 0.3 m. Geodynamic zones with quaternary movement speed gradient 10^{-9} m to 10^{-6} m a year.	II
,,	,,	Territories with quaternary movement speed gradient less than 10^{-10} m a year.	III
Residual seismic deformations: In the tectonic			

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
dislocation areas with width more than 10 m, at earthquakes of magnitude 7 – 9	Deformations Footing fissures	Displacements with amplitude of 0.3 m or more.	I
In the water-bearing soils	Fissures Settlement. Footing deformations	Displacements with amplitude of 0.1 m and more.	I
In the tectonic dislocation areas with suspended tectonic movements	Non-uniform settlement due to heterogeneous rocks in the basement of building structures crossing the area	Footing shelf is less than 0.3 m but more than 0.1 m; displacements with amplitude of less than 0.3 m but 0.1m or more.	II
At low-gradient slopes and altered areas at earthquakes with magnitude 7 – 9	Fissures. Settlement. Footing deformations	Displacements with amplitude of less than 0.3 m but 0.1 m or more.	II
In the tectonic dislocation areas, at slopes and lowland areas in defrosted soils at shocks with magnitude 4 – 6 induced by powerful explosions and earthquakes	Footing deformations	Displacements with amplitude of less than 0.3 m but 0.1 m or more.	II
the same	Fissures Settlement. Footing deformations	Displacements with amplitude of less than 0.1 m.	III
Earthquakes (of any genesis)	Oscillations of structures. Footing deformations. Subsidence. Alteration of ground water hydrological regime	Magnitude of SSE as per MSK-64 scale that is greater than 8	I
the same	the same	The same with magnitude 5-8	II
,,	,,	The same with magnitude less than 6	III
Volcanic eruption: In the area of volcanic bomb discharge, lava flows and explosion impacts	Displacements of footing. Impacts and high temperature effects. Toxic releases	Parameters are determined using history data and calculations	I

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
The same in the areas of ashes, gases and tremors	the same	The same but displacements are less than 0.3 m	II
Mud volcanism:			
In the areas of mud fountains and gaseous contamination	Mud flooding. Gas contamination. Temperature impacts. Footing deformations	Flood depth is 0.5 m or more	I
The same in the mud flow areas	Mud flooding	Flood depth is less than 0.5 m	II
Soil slips of any genesis, earthfalls and earth slip-falls moving and suspended with capture depth of more than 5 m	Displacement of footing soils	Area of displaced mass is 10,000 square meters or more	I
The same with capture depth of up to 5 m	Displacement of footing soils	Area of displaced mass is less than 10,000 square meters	II
Mudflows and snow and stone avalanches at slopes with inclination of 35 degrees or more	Shock, hydrodynamic impacts	Outwash volume is 100,000 m^3 or more	I
The same but less than 35 degrees	the same	Outwash volume is less than 100,000 m^3 or 2,500 m^3	II
the same	the same	Outwash volume is less than 2,500 m^3.	III
Erosion by water of shores, slopes and streams	On NF site: damages and fissures; settlements; footing depressions	Movements of truncation line and wave-cut bench are of 1 m/year or more.	I
the same	the same	Movements of truncation line and wave-cut bench are less than 1 m/year but 0.1 m/year or more.	II
the same	the same	Movements of truncation line and wave-cut bench are less than 1 m/year.	III
Sinks and subsidences, undergro und water erosion,	On NF site: settlements, footing depressions	One depression or more within the area of 10 square km or more.	I

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
including manifestations of karst			
the same	the same	One depression within the area of 100 square km.	II
Congelation and geologic (cryogenic) processes	Footing deformation	The design bases adopt maximum possible values determined for the specific site conditions.	II
Deformation of specific soils (thermokarst, dilution, solifluction, suffusion)	Footing deformations	The design bases adopt maximum possible values determined for the specific site conditions.	II
III. FACTORS CREATING MAN-INDUCED EXTERNAL IMPACTS (MAN-INDUCED FACTORS)			
Aircraft and other projectile crash	Impact, fuel spill, fuel combustion, fire	Possible aircraft mass is more than 20 tons.	I
the same	the same	Possible aircraft mass is 5 tons or more but 20 tons or less.	II
,,	,,	Possible aircraft mass is less than 5 tons.	III
Fire due to external causes	Hazardous fire factors (smoke, environ temperature increase, toxic products, heat decomposition burning, reduced oxygen concentration	Equivalent fire damaged area is 10 square km or more; combustible material inventory provide for burning and impact to NF for more than 2 hours.	II
the same	the same	The same but impact to NF is for 2 hours or less.	II
On-site explosions	ASW (air shock wave), projectiles, smoke, gas, dust, accompanying fires	Pressure impact at ASW front is 30 kPa or more	I
the same	the same	Pressure impact at ASW front is less than 30 kPa but 1 kPa or more	II
,,	,,	Pressure impact at ASW front is less than 1 kPa	III

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
Release of explosive, flammable and toxic gases and aerosols into the atmosphere, drifting cloud explosions	ASW, projectiles, smoke, gas, dust, accompanying fires, soil oscillations	Pressure impact at ASW front is 30 kPa or more.	I
the same	the same	Pressure impact at ASW front is less than 30 kPa but 1 kPa or more.	II
,,	,,	Pressure impact at ASW front is less than 1 kPa.	III
Releases of toxic vapors, gases and aerosols into the atmosphere	Increase in concentration of toxic gases and aerosols	Design parameters exceed permissible limits.	II
the same	the same	Design parameters are less than the permissible limits.	III
Corrosive liquid discharges to surface and groundwater	Corrosive precipitation at the facility. Ingress of corrosive fluid into the water cooling system's units from water intakes. Ingress of corrosive media into air suction systems, etc.	Design parameters exceed permissible limits.	II
the same	the same	Design parameters are less than the permissible limits.	III
Electromagnetic pulses and radiation	Impacts produced by electromagnetic field to the utilities, equipment and personnel	Parameters are determined by calculations for specific conditions.	II
Spills of oil and petroleum products at the coastal areas of rivers, seas and oceans	Heat flow impacts, corrosive impacts, etc.	Parameters are determined by calculations for specific conditions.	II
Break of natural and artificial reservoirs	Underflooding of the area, scour of water channels, dynamic impacts	Wave height is 1 m or more; water current velocity is 0.7 m/s or more	I
the same	the same	Wave height is less than 1 m but not higher than	II

Process, Phenomenon, Factor	Possible Impacts to NF Site and Facilities	Parameter Ranges to Determine Hazard Degree Categories	Hazard Degree Based On Consequences To Environment
the same	the same	0.2 m; water current velocity is less than 0.7 m/s. Wave height is less than 0.2 m.	III

NOTE:

1. When identifying phenomena, processes and factors one shall be guided by the following definitions of processes, phenomena and factors:

AIR SHOCK WAVE shall mean the shock wave which is generated by a pressure jump, which propagates at a high speed in the atmosphere of compressed-depressurized air.

AIRCRAFT AND OTHER PROJECTILE CRASH shall mean the external events affecting NF by aircrafts or their fragments in case of crash and by airborne objects (in the form of fragments of buildings, structures and vehicles) moved by excessive pressure of ASW resulted from explosion or wind or tornado or whirlwind.

BREAK WAVE shall mean the wave formed as a result of the pressure front break at a hydraulic structure or natural reservoir.

CONGRELATION-GEOLOGIC (CRYOGENIC) PROCESSES shall mean the processes characterized by frost-shattered fissuring, frost swelling which occur due to periodic freezing and defrosting of soils.

CORROSIVE LIQUID DISCHARGE INTO SURFACE AND GROUNDWATER shall mean the ingress into water of contaminants in quantities and concentrations, which alter composition and properties of water, and produce corrosive effects to underground utilities and underground structures.

DILUTION shall mean the loss of strength and rigidity of water saturated soils under dynamic impacts (earthquakes, explosions, vibrations).

DRIFTING CLOUD EXPLOSION shall mean the explosion resulted from the ignition of flammable gas leaks in the form of clouds, which, while moving at long distances, may retain flammable concentration during a long period of time.

EARTHQUAKE (OF ANY GENESIS) shall mean the underground thrusts and oscillations of earth surface resulted from pulse displacements and fissures in the crust.

ELECTROMAGNETIC PULSES shall mean the pulses of high-power short-time radiation emitted by an electromagnetic field source.

ELECTROMAGNETIC RADIATION shall mean the man-induced impact in the form of a radiation caused by generation of a free electromagnetic field by a source.

EROSION BY WATER OF SHORES, SLOPES AND STREAMS shall mean the deformation processes of erosion, disintegration of sea coasts and banks of lakes, water reservoirs, large rivers in the tidal wave areas accompanied by formation of bench and in-shore shoal, as well as erosion, transfer and re-deposition of soil and rock on slopes and in the streams of rivers and gullies caused by surface water streams.

ERUPTION OF VOLCANO shall mean the ejection from the volcano crater of incandescent

ash, sand and stones, egress of incandescent lava, which forms lava flows, incandescent avalanches, scorching clouds, ashfalls, mud flows, noxious gases.

EXPLOSION AT FACILITY (NUCLEAR FACILITY OFF-SITE EXPLOSION) shall mean the external impact from an explosion source which occurs outside NF site, where a large amount of energy is released within a short period of time.

FIRE DUE TO EXTERNAL CAUSES shall mean the fire initiated as a result of impacts to NF from natural and/or man-induced processes, phenomena and factors off-site the NF.

FISSURE SEISMIC AND TECTONIC DISPLACEMENTS shall mean the pulse faults, dislocations, thrusts and other fissure movements of the crust sections along seismogenic faults and fissures approaching the earth surface in the regions of high seismisity (> of magnitude 8).

FLOOD shall mean the formation of free water surface above the territory due to high water, negative setups and elevation of water levels.

FLOODING shall mean the flooding with water of a territory within the river valley and settlements located at higher elevations as compared to the yearly flooded floodplains resulted from atmospheric precipitation in combination with other hydro-meteorological phenomena, for example, recurrent rainstorms and snowmelt.

FLOODING shall mean the intense and comparatively short-time elevation of water level, which ends up with a fast water recession and occurs irregularly.

GEOLOGICAL AND ENGINEERING-GEOLOGICAL PROCESSES AND PHENOMENA shall mean the processes and phenomena of natural origin occurring in the upper layers of the crust and representing the effects caused by energy sources to the crust present inside it (endogenic energy sources) or outside it (exogenetic energy sources) or their combination. Endogenic energy sources and exogenetic energy sources can be of natural and man-made.

GRAVITATIONAL AND INCLINATIONAL ENDOGENIC PROCESSES shall mean the earthfalls, soil slides, crushed and block avalanches, mudflows in high seismisity areas (> of magnitude 8) and active recent tectonics at high rock slopes, which facilitate formation of unstable slopes.

GRAVITATIONAL AND INCLINATIONAL GEOTECHNOGENIC PROCESSES shall mean the initiation and activation of soil slips at slopes due to disafforestation, undercutting of slopes by channels followed by filtration of water, high-yield explosions and other man-made impacts, which reduce strength of rock and build-up stresses in slopes.

HIGH WATER shall mean the water regime phase of a river featuring seasonally occurring prolonged and significant rises of the river water mass, which cause smooth elevation of the water level.

HURRICANE shall mean the prolonged destructive wind (12 points and more of the Beaufort number) of speed 35 m/s and higher.

HYDROMETEOROLOGICAL PROCESSES AND PHENOMENA shall mean the processes and phenomena occurring in the atmosphere and hydrosphere, which are characterized by air mass movement parameters, moisture rotation, temperature regime, hydrology of seas, oceans, rivers and by other parameters.

ICE GORGE shall mean the accumulation of loose ice in the streamway.

ICE JAM shall mean the accumulation of ice in streamway, which prevents the normal flow and causes elevation of water level in the ice accumulation location and upstream of it.

KARST shall mean the combination of phenomena associating with water activity (surface and groundwater) and manifesting itself in dissolution of rock and cavity formation of various size and shape in them, and in formation of a specific groundwater circulation and regime and characteristic of terrain relief and drainage net regime.

LIGHTNING STROKE shall mean the natural impact to the environment by an electric discharge forming between clouds or between clouds and earth surface.

MODERN DIFFERENTIAL CRUST MOVEMENTS shall mean the relative displacements of crustal blocks including tectonic creep.

MUD VOLCANISM shall mean the phenomenon accompanied by ejection of rock as a result of abnormally high intrastratal pressures in gas and fluid bearing rock.

MUDFLOWS shall mean the short-time (in average 1 to 3 hours) destructive flows overloaded with mud and stone matter, which resulted from abundant rainfalls or snow melt in the piedmont and mountain regions, river basins, ravines with high inclination of thalweg (> 0.1).

NATURAL AND MAN-INDUCED CATASTROPHE shall mean the catastrophe initiated by external impacts of natural or man-induced origin and accompanied by the consequences of global or regional scale associating with irreplaceable damage to the environment involving great casualties, direct economic losses and consequence mitigation expenditure.

POSITIVE SETUP OF WATER shall mean the elevation of level caused by wind affecting the water surface.

RELEASE OF EXPLOSIVE, FLAMMABLE, TOXIC VAPORS, GASES AND AEROSOLS INTO THE ATMOSPHERE shall mean the ingress into air of contaminants in such quantities and concentrations that change the composition and properties of significant air mass volumes and negatively affect humans and environment.

RESIDUAL SEISMIC DEFORMATIONS shall mean the cracks, stepped subsidence, fold-thrusts, soil ejections, soil eruptions, precipitation, and earthquake waves formed as a result of seismic wave movements.

SEICHES shall mean the oscillations of a closed or half-closed water reservoir in response to a disturbing force of atmospheric, oceanographic or seismic origin.

SEISMIC ISOLATION OF STRUCTURE (BUILDING) shall mean the combination of engineering structures arranged, as a rule, in the structure foundations, which provide for reduction of oscillations of the structure being isolated with regard to seismic oscillations of the foot soils, as well as components and systems which provide for control (shift) of intrinsic frequency values of the structure (to the required range).

SINKS AND SUBSIDENCES shall mean the negative relief shapes resulted from soil collapse in the vaults above karst, thermokarst and mined cavities, as well as due to pumping out of water, oil and gas.

SNOW AND STONE AVALANCHES, CRUSHED AND BLOCK AVALANCHES shall mean the sliding of concentrated snow-stone and crushed-block masses from mountain slopes due to gravity and dynamic loads (seismic, seismic-explosive).

SNOW AVALANCHES shall mean the motion of concentrated masses of snow falling or sliding from mountain slopes in the form of a solid body (wet avalanches) or dispersed snow (dry avalanches).

SOIL SLIPS shall mean the movement of rock masses (soil) along the slope due to gravity and load (seismic, filtration, vibration, man-induced).

SOLIFLUCTION shall mean the slow movement (at velocity of 3 to 8 cm per year) of wet finely dispersed or dust-like soils down the slopes as a result of multiple swelling due to freezing and sinks due to melting, as well as under gravity. Each «freezing – melting» cycle leads to a displacement of the upper layer of loose deposits.

SPECIFIC SOILS shall mean the soils, which change their properties and characteristics in time within the time periods commensurable with the facility service life. They include frozen soils, subsided soils, swelling soils, loose soils, limy soils, eluvial soils, artificial soils.

SUFFOSION PROCESSES shall mean the decompaction of loose soils by groundwater with evacuation of small fractions of or the total soil mass. At this, the suffosion caverns are formed with sinks and subsidences of the earth surface above them.

TECTONIC CREEP shall mean the slow relative displacements of the crustal blocks along the active fissures and faults.

THERMOKARST shall mean the processes of melting of ice bodies embedded in frozen rock or melting through of the deep icy dispersed rock resulting in sinks and subsidences.

TORNADO shall mean the powerful, destructive small-scale atmospheric vortex (up to 1,000 m in diameter) where wind is rotating at a high speed (up to 100 m/s), which forms in the storm clouds and propagates downward, often down the earth surface, in the shape of a dark cloudy sleeve or proboscis of tens or hundreds meters in diameter. It exists for a short period of time and moves along with the cloud. It consists of fast rotating air, moisture particles, sand, dust and other suspensions. It features high wind speed in the cone, atmospheric pressure drop in its middle and shock impacts caused by airborne objects.

TROPICAL CYCLONE shall mean the gigantic atmospheric vortex with air pressure decreasing towards the center and anti-clockwise air circulation about the center, which occurs in the Northern Hemisphere, and clockwise air circulation about the center, which occurs in the Southern Hemisphere.

TSUNAMI shall mean the water surface oscillations as a sequence of waves formed by pulse disturbances of a water reservoir initiated by displacements associated with underwater earthquakes, volcanic eruptions, underwater soil slips, coast line earthfalls.

TYPHOON shall mean the powerful tropical cyclone featuring wind speed of more than 32 m/s.

2. The Table contains options when the following is indicated for processes, phenomena and factors:

a) limiting values of maximum parameters are indicated for Hazard Degrees I, II and III;

b) limiting values of maximum parameters are indicated for Hazard Degree I only;

c) limiting values of maximum parameters are indicated for Hazard Degrees II and III;

d) limiting values of maximum parameters are indicated for Hazard Degrees II.

Examples of the use of Appendix 1 data

Option a): a process, phenomenon or factor may be of Hazard Degree I, II or III. After the design values of maximum parameters are obtained they are used to meet the Rules of Ensurance of Stability of Safety of NF under External Impacts.

Option b): depending on intensity or by definition a process, phenomenon or factor can be attributed to the most hazardous (Hazard Degree I); its fact of on-site occurrence indicates that a decision-making is required to select (replace) another site due to presence of an especially hazardous process, phenomenon or factor at this site. The facility safety ensurance capability and its economic efficiency are assessed.

Option c): a process, phenomenon or factor is not constraining for the siting. These phenomena shall be considered in the design bases. Its design parameter values can be equal or exceed the numerical values determining Hazard Degree II. If an event of Hazard Degree III, it is permitted not to consider it in the design (owing to insignificant sequences of its impact to the environment).

Option d): for some types of processes, phenomena or factors the numerical values of Hazard Degree I, II and III are not established. But these processes, phenomena and factors, which are characterized by on Hazard Degree II, cannot be ruled out of the design bases. Irrespectively of

intensity, the design bases adopt the maximum design value determined for the specific site conditions (for example, a lightning stroke).

APPENDIX 2: LIST OF INTERRELATED AND INTERDEPENDENT PROCESSES OF NATURAL ORIGIN (REFERENCE)

Typical Combination of Geologic Processes	Form of Interrelation
Earthquakes, landslides, earthfalls	Intensification of landslides and earthfalls as a result of a severe earthquake
Landslides, earthfalls, mudflows, flooding, stream or gully erosion	Detention of valleys and gullies by moving landslide or earthfall masses a break of which leads to the formation of mudflows, aggravation of erosion and flooding of the areas
Karst, suffosion, landslides	Intensification of karst formation process is accompanied by suffosion processes and sliding of soil into the formed bedding caves
Reservoir bank transformation, landslides, earthfalls, karst	Reservoir bank transformation leads to intensification of landslide, earthflow and karst processes
Eolation, deep creep, landslides, earthfalls	Intensive eolation of rock aggravates creep processes followed by landslides and earthfalls
Stream or gully erosion, landslides, earthfalls	Intensive erosion initiates landslides and earthfalls
Landslides and earthfalls	Transition of a landslide process to the earthfall one (landslides-earthfalls) or an earthfall process to the landslide one (earthfalls-landslides)
Marine abrasion, landslides, earthfalls	Intensification of marine abrasion aggravates landslides and earthfalls
Excess drainage of areas, subsidence of the earth surface, eolation processes	Excess drainage leads to subsidence of the earth surface and intensification of eolation processes
Underflooding, swamping, karst, suffosion, contamination of soils	Underflooding of area is accompanied by swamping, karst and suffosion processes and contamination of soils and ground water, the latter intensifying dissolving and aggressive capabilities
Earthquakes, geodynamic and tectonic activity	Intensification of seismic activity as a result of aggravation of geodynamic and tectonic activity
Earthquakes, changes in geotechnical properties of soils within time	Changes in the site seismic conditions as a result of changes in geotechnical properties of soils
Changes in geotechnical properties of soils, karst and suffosion properties and engineering activities of man	Changes in geotechnical properties of soils due to karst and suffosion processes, site underflooding or drainage, compaction of soil by the building weight, etc.
Earthquakes, engineering activities of man (mining of oil, gas, natural reserves	Induced seismic impacts, deformation of the earth surface

Typical Combination of Geologic Processes	Form of Interrelation
(including coal and rock-salt), pumping in industrial wastes and inundation of reservoirs, impounding, fast water discharge from reservoirs)	

APPENDIX 3: SOURCES OF INFORMATION NECESSARY FOR IDENTIFICATION OF NATURAL AND MAN-INDUCED PROCESSES, PHENOMENA AND FACTORS ANALYSIS (REFERENCE)

Hazardous Processes, Phenomena, Factors	**Information Sources**
I. HYDRO-METEOROLOGICAL PROCESSES AND PHENOMENA	
Flood (flooding)	Topographic and climatic maps Historical data. Surface water resources. Hydrologic year-books. Witness reports. Archived data. Hydrological monitoring. Statistical data obtained through processing of hydro-meteorological information for a long time period (not less than 50 years), which contains sets of annual parameter values and peaking data. Systematic data collected within, at least, one year in the area surrounding the site. The sizes of such areas shall be sufficient to take account of all regional features and factors affecting climatic conditions of the given region. Measurement data obtained through standard hydro-meteorological survey programs, which provide for hourly measurements performed directly on the candidate site. Climate handbooks. Climate monthly and yearly books. Aerial and meteorological monitoring.
Tsunami	the same
Watercourse icing (ice jams, ice gorges)	,,
Coastal situations (positive and negative setups, storms)	,,
Seiches	,,
Tides	,,
Changes in water resources (extremely low flow, abnormal decrease in water level)	,,
Tornado	,,
Wind, hurricane	,,
Tropical cyclone (typhoon)	,,
Atmospheric precipitation	,,
Extreme snowfalls and snowpacks	,,

Hazardous Processes, Phenomena, Factors	Information Sources
Air temperature	,,
Snowslide	,,
Glaze-ice	,,
Lightning stroke	,,
II. GEOLOGICAL AND ENGINEERING-GEOLOGICAL PROCESSES AND PHENOMENA	
Fissure seismic and tectonic displacements, seismic dislocations, seismic and tectonic upswelling and downswelling of crustal blocks	Literature and archives on structural geology, geomorphology, Quaternary tectonics, seismic tectonics, geophysics, seismology, deep-seated structure and modern crust movements, seismisity, quaternary seismic dislocations. Space and air survey images. Geophysics, geochemistry and geodetic surveys of fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of modern fissure geodynamics including high-accuracy recurrent leveling and instrumental monitoring of micro-earthquakes. Results of integral geologic and geophysical survey. Data acquired in the course of boring, sinking, electric and seismic survey profiling, well logging.
Modern differential crust movements including tectonic creep	The same
Residual seismic deformations of crust	"
Earthquakes of any genesis	"
Volcanic eruption	,,
Mud volcanism	,,
Soil slips	Geodetic, air and space survey, engineering and geologic and geophysics monitoring. Documents generated in the course of engineering surveys (geodetic and hydrometeorological) carried out for the purposes of constructing in the regions featuring hazardous geologic processes (including seismic regions). Documents of engineering protection from hazardous geological processes.
Earthfalls and earth slip-falls	The same
Mudflows	,,
Snow and stone avalanches, crushed and block avalanches	"
Erosion by water of shores, slopes and streams	"
Sinks and subsidences	"
Underground erosion	"

Hazardous Processes, Phenomena, Factors	**Information Sources**
including karst formation	
Congelation and geologic (cryogenic) processes	"
Deformation of specific soils (thermokarst, dilution, solifluction, suffusion)	"
III. FACTORS CREATING EXTERNAL MAN-INDUCED IMPACTS (MAN-INDUCED FACTORS)	
Aircraft and other projectile crash	Maps containing information on location of airports, air corridors, intersection points of air routes in the NF location region. Air traffic data, aircraft types and their specifications, flight frequency. Aircraft take-off, landing and idling schemes. Information on availability of military facilities using bombing shooting ranges within NF impact area. Data on variety of possible projectiles, their characteristics, frequency of occurrences. Archived data on aircraft crashes.
Fire due to external causes	Regional map indicating all possible ground sources of external fire hazard: - forests - explosives' storage facilities (solid, liquid and gaseous) - product pipelines and main oil and gas pipelines - railways and highways, river and marine routes - airfields, air traffic routes - residential areas - industrial sites (with indication of categories of rooms, buildings and open-air process facilities as regards fire and explosion hazard) - coal and peat mines - peat deposits areas - water surface areas with indication of oil and oil product spills Archived and statistical data on fires and their causes in the region for recent 5 years, at least Combustible material resource data Weather conditions Hydrologic conditions
On-site explosions	Regional map indicating locations of stationary and mobile potential explosion sources:

Hazardous Processes, Phenomena, Factors	Information Sources
	• storage facilities containing explosives • facilities employing hazardous technologies, which make possible on-site explosions, high pressure vessels and installations containing gases, vapors or overheated liquids • highways and railways, water transport, as accompanied with explosives traffic data • main oil and gas pipelines, product pipelines, process equipment or pipelines carrying combustible gases and flammable liquids, where leakages may occur to lead to explosion and fire hazardous cloud formation • military facilities Information on explosives in storage Archived and statistical data on explosions in the area Geological situation in the region and at NF site Weather conditions Hydrologic conditions A map of external sources (with regard to the radioactive source) of explosions on the NF site
Releases of explosive, flammable and toxic vapors, gases and aerosols into the atmosphere, drifting cloud formation	Maps indicating locations of sources of toxic releases from chemical plants; sources of fires Diagrams showing traffic routes of mobile toxic sources. Dispersion of admixtures in the atmosphere Information on possible amounts of toxic releases Weather data, including inversion and fog information
Corrosive liquid discharges into surface and groundwater	Maps indicating locations of industrial facilities using chlorine, hydrogen sulfur, ammonia, sulfur dioxide and other chemically aggressive substances, and location of corrosive substance discharges of such facilities Diagrams showing traffic routes of mobile corrosive sources. Surface and ground water dispersion of admixtures Information on possible amounts being discharged (released) Archived and statistical data on discharges Hydrological conditions
Electromagnetic pulses and radiation	Maps showing enterprises, military and other facilities featuring electromagnetic radiation and involved in generating and use of electromagnetic fields Special information on source capacity
Spills of oil and petroleum products at the coastal areas of rivers, seas and oceans	Maps showing sea and oceanic coastal surface areas, facilities housing oil products and oils, marine traffic routes Information on possible spillage of oils and petroleum products.

Hazardous Processes, Phenomena, Factors	Information Sources
	Possible spill sizes (archived and statistic data) Weather conditions. Hydrological dispersion of admixtures in the coastal areas of rivers, seas and oceans
Break of natural and artificial reservoirs	Water reservoirs and NF location atlas Topographic and climatic maps Seismisity of the region. Surface water resources. Hydrologic year-books. Inventory data Hydrological monitoring Probabilistic reliability characteristics of hydraulic structures reliability under external natural and man-induced impacts Statistical data obtained through processing of hydro-meteorological information for a long time period (not less than 50 years), which contains sets of annual parameter values and peaking data Data of annual water level measurements in the headwater Statistical assessments of maximum water amounts in the headwater Measurement data obtained through standard hydrometeorological survey programs, which provide for hourly measurements performed directly on water surface adjacent to the NF candidate site

APPENDIX 4: BASIC PARAMETERS DESCRIBING NATURAL AND MAN-INDUCED PROCESSES, PHENOMENA AND FACTORS (REFERENCE)

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
I. HYDRO-METEOROLOGICAL PROCESSES AND PHENOMENA	
Flood	Maximum water flow rates and levels Hydrographs of rainfall flood and spring flood
Tsunami	Area flooding and maximum tsunami backrush Wave height, wave velocity, flooding time
Watercourse icing (ice jams, ice gorges)	Thickness of ice Sizes of individual floes Floes speed Floes coast advance angle Width and length of ice jams and ice gorges Frequency of ice jams and ice gorges formation Ice phase occurrence time
Coastal situations (positive and negative setups, storms)	Wave height Sea wave time Water level
Seiches	Peak reservoir water level variations
Tides	Extreme tide levels
Changes in water resources (extremely low flow, abnormal decrease in water level)	Minimal flow Minimal water level
Tornado	Design intensity class of tornado as in Fujita scale Path length/width Tornado wall peak horizontal rotation velocity Tornado translatory velocity Center to periphery pressure differential in the rotational vortex Depressurization rate. Occurrence probability. Process cooling pond dewatering rate
Wind, strong wind	Peak wind velocity

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
Topical cyclone (typhoon)	Peak wind velocity Maximum daily precipitation
Atmospheric precipitation	Precipitation depth
Extreme snowfalls and snowpacks	Snow depth Snowing period duration
Air temperature	Minimum and maximum temperatures
Snowslides	Snowslide amount and speed. Snowslide deposit density and depth. Snowslide impact and shock wave force
Glaze-ice	Ice wall thickness
Lightning stroke	Mean and peak number of days of thunderstorms Atmospheric electric field strength/peak lighting power
II. GEOLOGICAL AND ENGINEERING-GEOLOGICAL PROCESSES AND PHENOMENA	
Fissure seismic and tectonic displacements, seismic dislocations, seismic and tectonic upswelling and downswelling of crustal blocks	On the high seismisity (equal or more magnitude 8) territory within 150-300 km radius from NF: - location of seismogenic surface rupture; rupture type (fault, shift, etc.); - rupture length; - amplitude of rupture slip (horizontal and/or vertical) - fractions of creep and seismogenic movements in slip amplitude; - rock in the burst edges and in the rupture zone; - location, length and width of the seismically active fissure zone including movement parameters (velocity and horizontal and vertical slip amplitude, inclination) at the edges and in the fissure zone before and after severe earthquake - soil disturbance parameters of «tear», loosening of soil, stone ejection - seismogenic layer thickness In case of predictable fissure seismic and tectonic displacements the same parameters as for tectonic creep, as well as geologic seismisity criteria.
Modern differential crust movements including tectonic creep	Location of tectonically active fissures, regional and other ruptures including buried ones Length and width of these fissure and rupture areas Structure of the tectonically active fissures and their break zones and sub-zones Uplift and subsidence velocity of tectonic blocks and wedges Velocity of tectonic creep for various movement modes (steady-state, variable, before and after earthquake) Displacement (uplifts, subsidence, shifts and inclination) of tectonic blocks

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
	and wedges Creeps within geological time and other time periods Non-uniform movement gradients with regard to time periods Age and amplitude of shifts of the youngest tectonic creeps and the profile in the relief
Residual seismic deformations of crust	The same
Earthquakes of any genesis	For each zone with possible focus of earthquake within the telluric radius from NF: - maximum magnitude - effective focus depth seismisity in the epicenter (magnitude as in MSK-64 scale) - seismic dislocations, seismic and gravitational processes and phenomena, break of pressure fronts - seismisity and consequences of hazardous geologic and hydrogeological phenomena in the NF site location - rock oscillation parameters at the surface and foot of the structure foundations (calculated or analog accelerograms and generalized response spectra; frequency rock characteristics and dynamic coefficients; maximum amplitudes of acceleration, velocity and shifts of horizontal and vertical oscillation constituents and corresponding frequencies and number of cycles)
Volcanic eruption	Volcanic activity (active, quiet, extinct) Characteristics of hazardous phenomena accompanying eruption of active volcano (lava flows, incandescent tuff flow, mud flows, floods, scorching cloud, poison gases) Height and slope of volcanic pile Type of volcano with regard to eruption features
Mud volcanism	Mud flooding rate – increment in the flood area within a year Mud level elevation rate Mud flooding area at the pre-set mud level Mud temperature on the flood area and in the spouting point Parameters of air contamination with gas
Soil slips	In case of active soil slips including the potentially seismic and gravitational: - location diagram and profiles - slope length and area - slope relief shapes (configuration, height, angle)

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
	- historical data, genesis and age of slope - bedding conditions in the slope massif of slackening surfaces and zones (including displacement surfaces) and physical and mechanic properties of rock (especially shearing strength) on these surfaces and zones - tectonic non-continuity of the slope rock, along with assessment of its effects to the soil slip activity - assessment of modern tectonic movements and seismicity effects to slip displacements - conditions of ground water level and pressure, and conditions of their discharge on the slope, along with assessment of ground water effects to slip activity - rates of weathering, erosion, underwashing of slope, degradation of stream channel, along with assessments of their effects to soil slip development - displacement mechanism: sliding, extrusion, spewing, flow, prompt dilution - slope coverage depth - character of movement: continuous, periodic, i.e within prolonged or geologic periods of time (as new forms) - velocities of movement along the slope (in steady-state, variable, before and after earthquake modes) - displacements along the slope within different time intervals - type, humidity and volume of slip soils
Earthfalls and earth slip-falls	In case of earthfalls on hazardous slopes: - locations of existing and anticipates earthfalls with volume of more than 10 cubic meters - earthfall slope height and steepness - slope surface shape - degree of erosion of the slope rock, availability of weakened zones, layers of plastic and suffosion unstable rock, tectonic fissures - resistance to shear, volume weight, rock humidity and modulus of deformation in the weakened zones and sub-layers and in crack filler - sizes and volume of the eventual earthfall - coming earthfall or earth slip-fall symptoms: inrush and fall of individual blocks, expansion of existing cracks and appearance of new cracks, crack narrowing, displacement, periodical cracking sound, small movements of rock blocks
Mudflows	According to formation mechanism they are differentiated as erosion, break, earthfall and earth slip-fall ones. According to formation conditions, they are differentiated as rainstorm (the most frequent), snow, glacial, volcanic (the largest ones), seismic (in regions with seismic activity of magnitude 8 and higher), technogenic, antropogenic ones. According to

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
	their content, they are differentiated as mud, mud and rock, water and rock ones. According to the mode of motion, they are differentiated as coherent and incoherent ones. Mudflow map covering area within 50 km radius from NF: - mudflow basin boundaries - drainage net, along with characteristic stream gradient; mudflow formation, movement and accumulation zones - glaciers, moraines, lakes and water reservoirs; hydraulic structures, mudflow protective structures and other facilities (including NF) On the mudflow basin map: - mudflow centers and amount of matter they contain - degree of erosion of the catch basin relief and mantle of soil and vegetative cover - mudflow streams and possible jamming locations; volume and activity of earthfalls, rockslides and soil slips in the mudflow streams' areas - mudflow deposit volume, area, depth and width in the mudflow accumulation zone On the possible mudflow movement map: - maximum velocity, depth, width and flow rate - mudflow flood areas (involving catastrophic failures, mudflow drift) - mudflow impact areas - zones of possible slop unstability due to underwashing - safe zones, evacuation routes - boundaries of existing and design facilities The report is to reflect: - genesis, initiating conditions, mechanism of formation, type and frequency of mudflows - maximum volumes of isochronous evacuation of mudflow mass and dynamic mudflow parameters - physical and mechanical properties of rock in mudflow centers and in deposit area
Snow and stone avalanches, crushed and block avalanches	They form at treeless slopes of slope inclination of 15 to 50 (more frequently 30 to 40) and length of 100 to 500 m. They depart via a steam channel or over the whole width of the slope area. In case of mountain slopes with avalanche hazard: - locations of avalanche hazardous areas, their morphology, avalanche routes - height, inclination, surface profile, degree of weathering - acceleration length along the slope, depth and cross-section of stream

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
	channel, locations of benches in the channel - sliding surface material (rock, soil, snow) - maximum traveling distance and volume of avalanche, maximum velocity, height and width of avalanche front in the building structure location - effective density of avalanche mass - maximum pressure of avalanche to building structure (dynamic, static) To assess the mean avalanche hazard degree on-site or on-route: - a number of centers per 1 km^2 of the site or per 1 km^2 of the valley floor length - a fraction of avalanche hazardous area of the total one - ratio of the avalanche affected valley floor length to the total length at the given section - fraction of stream avalanche centers in the total area of the avalanche hazardous slopes - mean width of stream avalanche traveling zone
Erosion by water of shores, slopes and streams	In case of wave abrasion of banks - annual volume of marginal degradation per bank length unit - length of active water erosion zone - travel of water edge and crest of a bench during a year In case of erosion by water of slopes and streams: increase in erosion separation degree, length and volume of gullies, travel of river stream, etc. over a year or other period of time
Sinks and subsidences of territory	The terrain stability categories with regard to sinks of various genesis (karst, thermokarst, suffosion, geological and technogenic exploration and water, oil, gas pumping-out) are established according to intensity of sink formation (number of sinks per year per unit of area) and to mean diameters of sinks or mean width of extended sinks. Negative relief forms (crusts, pores, cones, basins, poljes, valleys, cauldrons), their shapes and sizes in plane (area, length, width). In case of individual typical shapes: mean and maximum depth and sinking velocity of earth surface
Underground erosion including underground karst formation	In case of territories where the underground erosion manifests itself on the earth surface (karst, leaching suffosion): - deposit conditions of rock subject to underground erosion by groundwater - hydrogeologic erosion conditions - boundaries of sections with different underground erosion degrees The site underground erosion maps should show:

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
	- loss of integrity and destruction zones - cracks, caverns widened by dissolution, suffosion and leaching - channels, galleries, caves and other voids and their sizes - rock deposit failures resulted from their motion and collapse over the voids, failed and non-integral areoles - degree and content of void fills - zones weakened by tectonic processes - other manifestations of underground erosion Karst activity is to be characterized by a ratio of dissolvable rock volume to the volume of the element under assessment or the all massif expressed in percent over 1,000 years Suffosion rate is to be characterized by a volume of masses taken-out per year
Congelation and geologic (cryogenic) processes	Depth, thickness, lithologic composition, filtration properties, temperature, heat capacity and heat conduction of frozen and melted massif Capacity of work level Amount of heat transferred to the massif from facility Cryogenic processes and formations (solifluction, swelling hummock, winterkilling cracks, thermokarst, ice bodies), shapes and sizes of cryogenic formations (hummock diameter and height; depth, length, width and areas of thermokarst sinks and subsidences; thermokarst propagation depth; area, volume and thickness of ice bodies; sizes of winterkilling cracks) Cryogenic processes' rates (swelling rate, ice bodies' accumulation rates, solifluction motion velocities, deepening rate of sinks and subsidences)
Deformation of specific soils (thermokarst, dilution, solifluction, suffusion)	Basic parameters of specific soil subsidence: - modulus of deformation, specific adhesion and angles of internal friction under natural humidity and saturated conditions, their variability degree in plan and over the thickness - type of soil conditions with regard to subsidence, subsidence thickness of formation and its layers, their variations - relative subsidence - initial subsidence pressure
III. FACTORS CREATING EXTERNAL MAN-INDUCED IMPACTS (MAN-INDUCED FACTORS)	
Aircraft and other projectile crash	Probability of aircraft and other projectile crash of different classes on the given area during the facility service life: - rigidity characteristics of colliding bodies; - mass of bodies; - mass of fuel;

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
	- collision velocity; - collision angle; - impact direction; - collision area; - point of application
Fire due to external cause	Probability of fire Probability and speed of propagation of fire towards NF Equivalent fire affected surface area Heat flux within fire source and its variations towards NF Distance from NF Wind velocity and direction
On-site explosion	Excess pressure at the shock wave front Yield (TNT equivalent) Distance to NF Calculated concentration and gas toxic dose near NF Probability of explosive cloud to drift towards NF and of its flammability Capacity of ignition source
Releases of toxic vapors, gases and aerosols into the atmosphere, drifting cloud explosion	Initial concentration in the release location Atmospheric dispersion of releases Concentration as in primary sources and secondary hitting effects as the function of time taking the design intake and release of air Impact duration
Corrosive liquid discharges to surface and ground water	Initial concentration Concentration of corrosive media interacting with NF systems as the function of time and distance Impact duration Degree of damage to a system during a year of operation and the whole service life period Distance from discharge source and discharge location to NF
Electromagnetic pulses and radiation	Electric and magnetic field strength
Spills of oil and petroleum products at the coastal areas of rivers, seas and oceans	Oil slick area, slick thickness Chemical composition Distance to NF Distance to NF water intake

Processes, Phenomena, Factors	Parameters Incorporated into Design Bases
	Heat flux in fire source and its alteration towards NF Concentration of oils in the NF water intake location
Break of natural and artificial reservoirs	Wave height, wave velocity, territory flooding time

APPENDIX 5: LIST OF RECOMMENDED ENGINEERED PROTECTIVE FEATURES FOR NUCLEAR FACILITY SITE FROM EXTERNAL IMPACTS (REFERENCE)

A. EXEMPLARY LIST OF PROTECTIVE MEASURES FOR NF SITE

1. Control of surface and groundwater level.
2. Construction of protective structures preventing slopes and dips from washout, earthfalls, earth slips and other processes.
3. Construction of support walls, buttresses, pilings and other retaining structures preventing earth slips.
4. Arrangement of streamflow hydraulic structures, mudflow retaining and intercepting structures.
5. Groundwater draining.
6. Soil stabilization under building structure foundations.
7. Arranging for lightning protection.
8. Construction of protective structures against projectiles captured by tornado.
9. Anti-shock wave structure arrangements.
10. Banking or trenching to surround NF site, building of fire breaks and barriers to prevent external fire proliferation.

B. EXEMPLARY LIST OF ENGINEERED FEATURES TO PROTECT NF FROM EXTERNAL IMPACTS

1. Exemplary list of engineering features to protect NF from external natural and man-induced impacts includes:

- design of stable building foundations
- ensurance of building structures stability to extreme dynamic loads (from hurricanes, earthquakes, etc.)
- reduction of dynamic loads transferred by «soil-foundation-structure» system to the reactor, process and electrical equipment and other NF safety important elements
- protection of systems and elements from dynamic impacts.

2. It is recommended to implement the type seismic, impact and vibration protection measures:

- improve rigidity of structural elements of building structures, equipment, anchoring, and use features for disbracing of equipment, structures and pipelines
- reduce dynamic inertial loads affecting facility elements through seismic insulation of structures, equipment, pipelines, utilities, individual premises and building structures

- limit relative displacement and deformation of equipment, structural and pipeline elements to exclude unallowable deformations and collisions through employing special bumpers, compensators and dampers.

The listed measures may be implemented on the selective or integral basis.

The application of seismic isolation and dampers shall be justified in the design by:

- efficiency calculations;
- experimental verification of the proposed features or test data of their analogues.

The seismic insulation properly developed and experimentally verified shall be used. At this, the preference shall be given to the features that ensure three-component seismic insulation and insensitivity to frequency response of the impact.

3. Stability of the facility to loads produced by crashing aircrafts and other projectiles through:

- increase in cross-section areas of protective structures and their reinforcement rate, application of impact resistant structural materials, etc.
- improvement of the facility layout, redundancy of the safety important systems, space separation of such systems at safe distances, etc.
- installation of efficient shock absorbers at normal operation and safety important systems
- application of reliable fire suppression means
- implementation of technical and organizational protective measures to avoid the secondary effects of the projectile impacts (construction of protective barriers, etc.).

4. The NF protection from external explosions may be ensured through removal or screening of the explosion source or reinforcing of the NF building structures (improvement of rigidity and inertial cross-section parameters).

5. To efficiently improve fire safety and protect the facility from fires due to external causes, the design shall provide for:

- redundancy of safety important systems (components) allowing for their performing designated functions under fire;
- additional protective barriers;
- spatial and physical separation of safety systems, their channels and controlling safety systems; protection of shutdown and cooldown systems from damaging fire factors and provisions for these systems to perform design assigned functions during and after fire;
- streamline facility layout solutions; separation of process equipment, cable lines, piping and ventilation flows by fire walls (barriers) and safe distances to exclude a simultaneous fire impact to the main and back-up equipment;
- sufficient thickness of structural concrete;
- application of fire retardant materials; meeting the fire protection requirements regarding structures, rooms, buildings, building sections depending on their fire ratio and/or fire hazard;
- fire suppression systems, including in-door and out-door firewater systems;
- control over locations and amounts of on-site combustible explosion and fire hazardous

mixtures and substances;

- application of reliable sets of stationary automatic fire suppression and active fire localization systems;
- systems for warning and prompt information of the fire brigades; application of automatic fire alarms, fire notification of the employees.

The ventilation systems shall be designed taking into account the postulated external fire.

6. The protection of systems against corrosive liquid discharges shall be ensured through:

- application of corrosion resistant materials, protective coatings;
- thickening of pipe and equipment walls;
- application of protective leaktight housing for electronic equipment and instrumentation;
- application of aggressive gas detectors controlling stop valves;
- monitoring of cooling water chemistry, etc.

7. The following means are used to protect from toxic releases:

- toxic substance detectors;
- reduction of volume and concentration of toxic releases (ventilation, geometrical separation of flow);
- individual protective equipment.

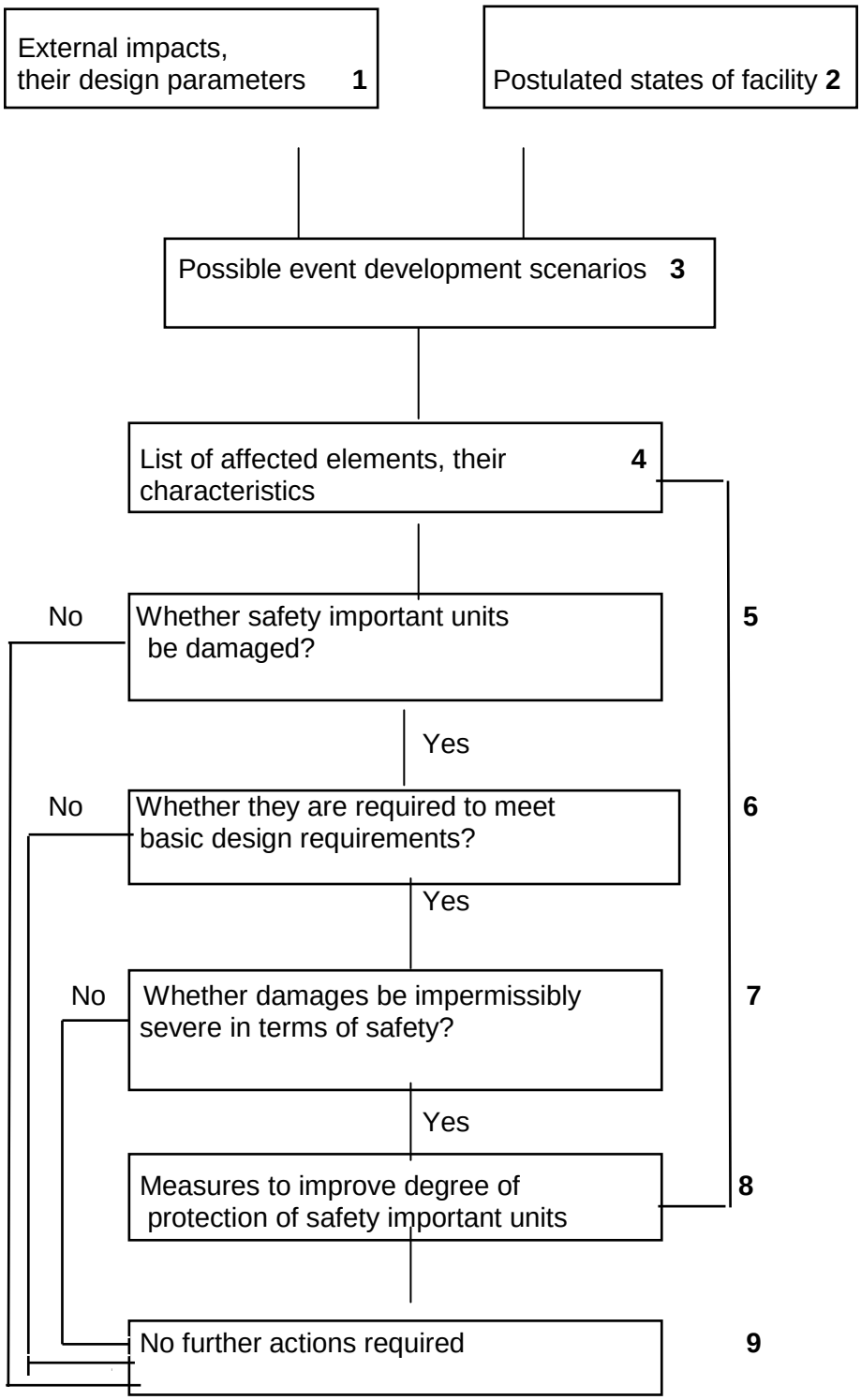
8. The following means are used to protect from lightning stroke, electromagnetic pulses and radiation:

- screens; optimum location of lightning protection systems;
- lightning arresters, dischargers, earthing of individual NF systems;
- overvoltage preventing devices in the most important locations;
- protection of inputs to a structure where induced currents and voltage may occur.

9. To protect NF water supply systems from ingress of oils and petroleum products the following shall be used:

- equipping of water intakes with oil and petroleum detectors;
- submerging of water intakes.

APPENDIX 6: LOGIC DIAGRAM OF NF SAFETY ANALYSIS UNDER EXTERNAL IMPACTS (RECOMMENDED)



A brief description of NF safety analysis under external natural and man-induced impacts

1. Types of external impacts considered in the design bases (Box 1 of the given Boxes 1 through 9 of Appendix 6) are identified along with their parameters.
2. The postulated states of NF are determined (Box 2).
3. A list of affected components is compiled and their characteristics and strength limits (Box 4) are determined on the basis of consideration of possible consequence scenarios (Box 3).
4. The responses of NF buildings, structures, systems and components to external impacts under consideration are determined. It is done deterministically employing (or not employing) probabilistic analysis elements (Box 5). It covers their damageability, as well as damageability of safety important units.
5. Safety analysis is performed aiming at risk assessment (Boxes 6 and 7). For newly designed facilities it is deterministically assessed whether they are compliant to meet the main design solutions. If the units are necessary, their protection measures are provided for. For facilities in operation it is allowed to assess the necessity of such units as regards performance of safety functions. If risk characteristics obtained are unacceptable due to failures of such units, the protection from external impacts of the type in question is implemented for such units.
6. After the protective measures are taken it is necessary to repeat the analysis steps as in Boxes 4, 5, 6 and 7 to verify sufficiency and compatibility of the protective measures with regard to different types of impacts.

Note:

In some cases the detail consideration may avoid the events for which it is possible to demonstrate that the loads they cause are overlapped with the loads caused by other events under consideration (for example, in the majority of cases it is not necessary to take account of vibration of equipment resulted from external explosions if such equipment designed to withstand loads caused by earthquakes and aircraft crash). It is permitted to limit the analysis by a comparison of amplitude-frequency characteristics of external impacts, drawing up a statement on “relative insensitiveness” of the equipment to other impacts as compared to the main ones cover by protection.

APPENDIX 7: LIMITING PERMISSIBLE LOADS TO PERSONNEL (REFERENCE)

1. Limiting permissible acceleration levels to personnel without special provisions (standing and sitting positions) are 0.9 g along all coordinate axes (vector sum of accelerations).
2. In case hitting an obstacle with one's head the collision rate is not higher than 2.3 m/s.
3. In case collisions with secondary objects having masses of 1, 2, 3, 4 and 5 kg the collision rate should not exceed 5, 3.7, 3, 2.5, 2.2 m/s, correspondingly.
4. Permissible overpressure due to the shock should be less than 35 kPa.
5. Limiting permissible levels with regard to toxic and radioactive gases, aerosols, smokes, fire damaging factors, heat flux and air temperature in the room shall be as in applicable norms.

APPENDIX 8: RECOMMENDED COLLECTIVE AND/OR INDIVIDUAL PROTECTIVE EQUIPMENT (REFERENCE)

Affecting Factor	Recommended Protective Equipment	
	group protection	**individual protection**
Shock wave	Protective screens, booths	Special supporting arrangements in corridors (manropes, handrails, grab handles), safety belts at working places
Kinematics movements of structures: foundations, floors	Seismic and vibration absorbers	Specially designed chairs, hard caps, supporting arrangements (manropes, handrails, grab handles), mats
Local impact loads	Local seismic and vibration protection	Specially designed chairs, hard caps, supporting arrangements
Projectiles	Protective screens, guard meshes, impact protective structures (from objects with mass of 5 kg to 5 tons)	Hard caps
Fall down due to loss of balance	Seismic and vibration absorbers	Supporting arrangements
Caustic toxic and radioactive gases and aerosols, smoke		Respirators, breathing apparatuses
Hazardous factors, including increased temperature, heat radiation	Fire safe areas and layout solutions ensuring the personnel safety during fire damaging factor effects	Self-rescue breathing apparatus with compressed air, full-face oxygen masks (respirators)

APPENDIX 9. DATABASE FORMATS FOR NATURAL AND MAN-INDUCED PROCESSES, PHENOMENA AND FACTORS (MANDATORY)

The database purpose is to reflect NF site conditions during its service life and compile essential information on natural and man-induced processes, phenomena and factors affecting NF.

1. General information

1.1. NF name _____

1.2. NF commissioning/decommissioning year _____/_____

1.3. Location:
Russian Federation Subject
_____
Nearest city(ies)
_____
Distance from site to _____ km.
Azimuth (grade) _____

If the site is located near the state border (25 km and less from the state border) indicate the neighboring country (countries)
_____

1.4. Site geographic coordinates:
Latitude _____ Longitude _____

1.5. Site absolute marks per the Baltic System of Elevations (BS):
Natural: highest/medium/lowest _____/_____/_____ m BS.
Plans _____ m BS.

1.6. Landscape within 20-30 km radius

Brief description

Plain _____
Hilliness _____
Location in the hollow
_____
Location of rivers
_____
Coastal line of
lake/sea_____
Other (to be described)
_____

1.7. Population distribution:
Closest administrative center, village, town
Name_____
Distance / azimuth_____ km /_____
Population (number) _____ .
Closest city (50 000)
Name: _____

Distance / azimuth_____ km /_____
Population (number) _____.

2. Weather conditions

2.1. Whirlwind hazard zone as per zoning map _____

2.2. Whirlwind intensity as per Fujita Scale: _____

2.3. Maximum rotating speed of whirlwind side _____m/s

2.4. Whirlwind route length _____km

2.5. Whirlwind route width _____ km

2.6. Whirlwind cone periphery-to-center pressure differential _____gPa

2.7. Probability of whirlwind passing through the NF site _____

2.8. Probability of hurricane (tornado) passing through the NF site _____

2.9. Design characteristics of maximum hurricane (tornado) _____

2.10. Design maximum wind velocities of different probability including 1; 0.1; and 0.01 % _____, _____,_____ m/s

3. Hydrologic conditions

3.1. Type of water reservoir affecting the NF safety (river, lake, reservoir, sea)
_____

3.2. MWS formation factors considered in design

For rivers: spring flood, rain flood; dam break, clogging, ice jams and gorges, volcanic activity, earthquake, landslide, downfall, mudflow, etc. (underline relevant; indicate other factors) _____

For water reservoirs: wind setup, storming, maximum on-shore wave setup, seiche, tides, etc. (underline relevant; indicate other factors) _____

3.3. Absolute highest mark of observed (historic) water level in the reservoir _____ m BS

3.4. MWS parameters:

Maximum probability levels including
1; 0.1; and 0.01 % _____,_____,_____m BS.
Maximum wave height probability
including 1; 0.1; and 0.01 % _____,_____,_____m

For rivers

maximum water flow rate probability

including 1; 0.1; and 0.01 %_____,_____,_____m^3

For water reservoirs:
MSW level considering limiting flooding mark for coastal line with combination of design contributors (seiche, tides, wind setup, storm, tsunami) _____ m BS

peak seiche water level _____ m

the peak amplitude of the sea tide oscillations _____ m

design storm setup height at maximum wind speeds of various probability including 1; 0.1; and 0.01 % _____ , _____ , _____ m

highest wave at deep waters at maximum wind speeds of various probabilities including 1; 0.1; and 0.01 % _____ , _____ , _____ m

highest tsunami wave flood mark of various probability including 1; 0.1; and 0.01 % _____ , _____ , _____ m BS

lowest tsunami wave flood mark of coastal line including 1; 0.1; and 0.01 % _____ , _____ , _____ m BS

4. Hydrogeological and engineering-geologic conditions

4.1. The first from surface water-bearing horizon characteristics:

ground water level _____m/ _____m/ _____m BS.
lithologic characteristic of surrounding rock_____
rock permeability coefficient _____m/days.

rock active porosity _____%
existing water intake _____
maximum / medium / minimum absolute marks of ground water level

_____m/ _____m/ _____m BS;

4.2. The second from surface water-bearing horizon characteristics:

expansion area _____
absolute mark of lower / upper confining layer _____m / _____m BS.

ground water level max/med/min _____m/ _____m/ _____m BS.
lithologic characteristic of surrounding rock_____
rock permeability coefficient _____m/days.

rock active porosity _____%
existing water intake _____
maximum / medium / minimum absolute marks of ground water level at NF

_____m/ _____m/ _____m BS

4.3. Water confining layers:

expansion area _____
absolute mark of to / bottom of water confining level _____m / _____m BS
water confining layer rock lithographic characteristic

_____

rock permeability coefficient _____m/days.

presence of hydrogeological windows in water confining layer

_____

4.4. Engineering-geologic conditions:

specific soils: soft with module of deformation <20 MPa, uncompressible, sinking, swelling, saline, pergelisol

_____
_____
_____
_____

recent hazardous geologic processes and phenomena:

_____

presence of karst, suffosion, karst-suffosion, etc.

_____

5. Seismicity

5.1. Seismotectonic model of the region.

5.2. Detailed sketch of the region seismic zoning.

5.3. Sketch of structural and tectonic conditions of the neighboring region.

5.4. Sketch of seismic microzoning of the site regarding natural and man-induced conditions as changed.

5.5. Characteristics of spectra and duration of oscillations for distant, medium distant and local earthquakes.

5.6. Safe shutdown earthquake (SSE) and design basis earthquake (DBE) parameters of the closest seismogenic zones:

magnitude, focus depth *h*, distance to the seismogenic area *r*, seismicity *J* as per MKS-64 Scale at the reference soil of the site

Seismogenic zone number	Magnitude		*h*, km		*r*, km		*J*	
	SSE	DBE	SSE	DBE	SSE	DBE	SSE	DBE

5.7. NF site seismicity in case of SSE / DBE _____/_____.

5.8. Maximum amplitudes of horizontal oscillations on free area of the site plan in case of SSE / DBE: accelerations _____/_____m/s^2 ; velocity _____/_____cm/s

5.9. Maximum amplitudes of horizontal oscillations of rock top in case of SSE / DBE. accelerations _____/_____m/s^2 ; velocity _____/_____cm/s

5.10. Maximum amplitude of acceleration / velocity periods at the plan level in case of SSE / DBE _____/_____ s.

5.11. Horizontal to vertical acceleration ratio _____.

6. Aircraft crash

6.1. Minimum distance of site from air traffic routes, arrival route, any airport _____, _____, _____km

6.2. Distance to a large airport _____ km

6.3. Probability of an aircraft crash on site

Aircraft category	Probability of aircraft crash on site, 1/year		
	statistics	over 10 years forecast	over 50 years forecast

7. Emergency explosions off-site

7.1. Potential emergency explosion sources within 5-10 km radius:

components of chemical and oil refinery complexes; energy carriers storage facilities, explosives; pipelines for pumping over liquid and gaseous energy carriers – aboveground; defense facilities (underline the relevant).

7.2. Surface transport potential emergency explosion sources.

Traffic routes, ports, harbors, channels, railway stations, cargo flow characteristics.

Attachment: Contingency plan (scale 1:25,000).

8. Off-site fires

Potential fire sources within 2 km radius: forest, peatbogs, gas/oil/product pipeline, base/storage of combustible materials, navigation canal (underline the relevant).

Fire statistic data.

Attachment: Topographic and landscape map of the region indicating fire sources.

9. Toxic and corrosive emissions into atmosphere.

Off-site emission sources of vapors/gases/aerosols, corrosion fallouts (underline the relevant).

Attachment: Sketch of the emission sources' locations.